60211B/33 G04 Q75 MINA 07.02.75
UK SEC FOR DEFENCE *GB 1550-351
07.02.75-GB-005466 (15.08.79) F25b-29

Aircrew suit heating and cooling unit - with lightweight compact refrigeration system having evaporator with associated heat-exchanger

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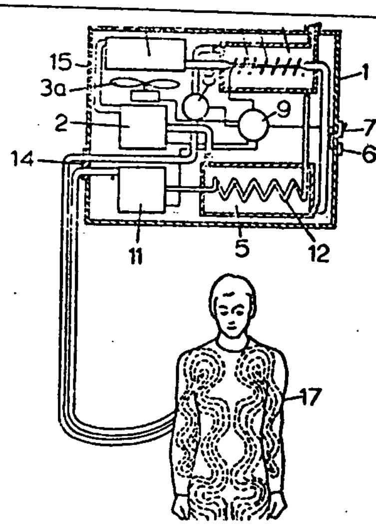
A unit comprises a refrigeration system with compressor, condenser, expansion capillary and evaporator, and a fluid supply system for connection to a recirculation circuit and including a heat-exchanger associated with the evaporator.

DETAILS

There is a heater for fluid flowing through the supply system and a temp. controller. The capillary is located so that heat transfers between refrigerant in and/or about to enter the capillary and the supply fluid around or emerging from the heater. The fluid is pref. air or aq. glycol, and the unit is of small size to allow stowage in a small cockpit. (4pp1358).



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PATENT SPECIFICATION (11) 1 550 351

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(21) Application No. 5466/75 (22) Filed 7 Feb. 1975
(23) Complete Specification filed 26 April 1976
(44) Complete Specification published 15 Aug. 1979
(51) INT. CL.² F25B 29/00
(52) Index at acceptance
F4H G2F G2L G2M G2R G2S
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(19) THE PATENT OFFICE LONDON

(54) APPARATUS FOR HEATING/COOLING CIRCULATION FLUID

(71) I, SECRETARY OF STATE FOR DEFENCE, LONDON, do hereby declare this invention for which I pray a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to apparatus for heating/cooling circulation fluid. It provides means whereby an environment can be chilled or heated as required, and is particularly concerned with a lightweight and economical pack suitable for controlling the micro-climate approximate to the skin of a human being.

According to the present invention a unit for providing supply fluid at temperatures within the range from cold to hot with respect to a given temperature datum, comprises a refrigeration system having a compressor, a condenser, expansion means in the form of a capillary and an evaporator, a fluid supply system adapted to be connected to a fluid supply re-circulation circuit and including a heat exchanger associated with the evaporator, a heating means for heating fluid flowing through the supply system, and a temperature control apparatus, the capillary location being so arranged that heat transfers between refrigerant in and/or about to enter the capillary and the re-circulation fluid around or emergent from the heating means.

While the heat transfer between the supply fluid and the refrigerant may be arranged prior to the capillary, it is constructionally advantageous for the supply fluid and the heater to be in heat exchange contact with the capillary as a three-way heat exchanger. It may also be advantageous to arrange that the supply fluid is in heat exchange contact with the capillary in a reservoir, perhaps having a filling facility, containing the capillary, and if so desired, the heating means which then preferably surrounds the capillary, is in the form of a coil. There may be an additional heating means for the supply fluid about to enter the evaporator. The unit may also have a pump in the fluid supply system, and the temperature control apparatus may include a temperature sensing means for sensing supply fluid output temperature, and a thermostatic control for the fluid supply temperature. It may be electrically powered, having a battery or means for connection to an external supply.

A reason for employing a capillary as the expansion means in a refrigerator is that it readily affords control of refrigerant flow to compensate for change in the temperature of the environment of the refrigerator. Nevertheless such compensation is normally insufficient to provide only nominal cooling when the temperature is only 1°C or 2°C above that required. To cater for this would necessitate the use of additional control means including intermittent switching arrangements, but this would have the disadvantage that it would add to the bulk and affect the reliability of the system. Moreover, in such a system, where both heating and cooling are available, to cool the fluid to below the desired temperature and then to reheat it in order to achieve a fine temperature control over a whole range chilled to hot, would mean an avoidable maximum consumption of power and that when the requirements of the load were at a minimum.

The rate at which a capillary passes liquid at any given pressure also depends inversely on the temperature of the liquid relative to the condensing temperature. Thus by linking the heating means of the heater circuit to the capillary as a heat exchanger one can, when cooling is required, arrange for the refrigerator circuit to present sub-cooled refrigerant to the capillary so that maximum flow thereof can

be obtained through the capillary. In this mode the heating means would normally be switched off. For nominal cooling the heating means may be switched on to cause vaporisation of refrigerant in the capillary and hence a reduction of flow therethrough. The invention thus has the advantage of providing a more economical way of achieving the required control through the temperature range, than the cooling and reheating mentioned above. When heating is required the compressor can be switched off and the temperature of the supply fluid controlled solely by the heating means.

One embodiment of the invention is particularly suitable for application to liquid conditioned suits of the type mentioned in UK Patent Specifications 992929 and 1115414 these being in the form of garments having pipes therein for the passage of the supply fluid. Such suits were especially developed to be worn by aircrew in uncomfortable environments. The unit is also applicable to the Baby Cooler described in UK Patent Specification 1,462,033. Such a pack could have an overall volume of about 2500 cm^3, a weight of about 5 kg, and provide temperature control energies of 200 watts of heating at 0°C environment temperature through to 300 watts of cooling at 55°C.

For use with liquid conditioned suiting the supply fluid medium is of course a liquid, usually a water glycol. Units in accordance with the invention may well be suitable, however, for use in an air conditioning system, where the supply fluid medium will be air. Indeed such a unit could have an additional fan and be suitable for a manually portable air conditioner.

A particular embodiment of the invention will now be described, by way of example with reference to the drawing accompanying the Provisional Specification, which is a schematic diagram of a unit linked to a liquid conditioned suit. The unit comprises a case 1 containing a refrigerator system, a temperature control apparatus and a liquid supply system. The refrigerator system comprises a compressor 2, a condenser 3 with a fan 3a, a capillary 4 and an evaporator 5. It is charged with a refrigerant such as Refrigerant 12 (dichlorodifluoromethane).

The temperature control apparatus comprises a supply socket 6, an on/off control 7, a temperature transducer 8 which senses the temperature of the output liquid from the unit, and a heating element 10; all of which are electrically connected to a manual temperature control 9. The liquid supply system comprises a pump 11, a first heat exchanger 12 in the evaporator 5, a second heat exchanger 13 associated with the heating element 10 and the capillary 4, and a fluid inlet and outlet self sealing socket 14.

The case 1 has perforations 15 in the region of the fan 3a, for allowing the fan to pass environmental air over the condenser 3. The heat exchanger 13 acts also as a reservoir for the liquid circuit and has a filler cap 16 on the casing 1. The temperature control 9 controls the compressor 2, the pump 11, and the heating element 10 in response to signals from the temperature transducer 8. The fan 3a is driven by the compressor 2. A liquid conditioned suit 17 is shown connected to the socket 14.

The unit is prepared for use by filling the liquid circuit at 16 with a liquid such as water glycol, and by connecting the pack to a suitable electricity supply. The suit may be separately filled with the same liquid and plugged to the unit at 14.

To operate the unit it is switched on at 7, when the pump 11 circulates liquid in the liquid supply through the heat exchangers 12 and 13 and the suit 17 in that order. Using the control 9 the user selects the liquid flow and temperature he requires.

If the selected temperature of the liquid is below that presently sensed at 8 the compressor 2 is switched on by the temperature control and the heating element 10 is switched off. The compressor takes refrigerant vapour from the evaporator 5 compresses it and passes it to the condenser 3. Liquid refrigerant from the condenser passes to the capillary 4 and thence to the evaporator 5. In the evaporator the refrigerant removes heat from the liquid in the heat exchanger 12. The chilled liquid then passes through the heat exchanger 13, wherein by cooling the capillary 4 it assists the flow of refrigerant therethrough and thus increases the amount of cooling.

For much of the available cooling temperature range, control of the coolant temperature is augmented by the variation of environment temperature to the condenser 3. The higher the environment temperature, the greater the pressure in the condenser and hence of the liquid refrigerant in the capillary, and the greater the cooling available in the evaporator.

If the selected liquid temperature is slightly higher than the sensed temperature the heating element 10 will be switched on. This warms both the liquid in the heat exchanger 13 and the refrigerant in the capillary 4. The latter becomes superheated and due to the formation of vapour bubbles therein flow through the capillary is restricted and less cooling becomes available in the evaporator 5. At the same time the liquid in the liquid supply is being warmed at 13 to the selected temperatures.

If a considerably high liquid temperature is required the compressor 2 is switched off and the heat of the liquid is modified solely

by the heating element 10. The output of the heater is controlled by the temperature difference between sensed and required temperature. Typically the heater may be off when the temperature selected is below 30°C and the compressor off when the temperature selected is above 35°C.

Such a pack can measure about 8 cm × 12 cm × 26 cm and weight about 5 kg. Using a 3-phase 400 Hz aircraft supply it can provide 200 watts of heating at 0°C to 300 watts cooling at 55°C, with 200 watts of cooling being available at temperatures above 55°C up to 65°C. It is thus particularly suitable for use by aircrew in aircraft cockpits in extreme climates, when the small size of the pack should permit it to be stowed in the cockpit.

WHAT I CLAIM IS:

1. A unit for providing supply fluid at temperatures within the range from cold to hot with respect to a given temperature datum, comprising a refrigeration system having a compressor, a condenser, expansion means in the form of a capillary and an evaporator, a fluid supply system adapted to be connected to a supply fluid re-circulation circuit and including a heat exchanger associated with the evaporator, a heating means for heating fluid flowing through the supply system, and a temperature control apparatus, the capillary location being so arranged that heat transfers between refrigerant in and/or about to enter the capilary and the supply fluid around or emergent from the heating means.

2. A unit as claimed in claim 1 in which the fluid supply system is combined with the supply fluid re-circulation circuit.

3. A unit as claimed in claim 1 or claim 2 and arranged so that the supply fluid and the heating means are in heat exchange contact with the capillary as a three-way exchanger.

4. A unit as claimed in claim 3 and having a reservoir containing the capillary whereby the supply fluid can be in heat exchange contact with the capillary.

5. A unit as claimed in claim 4 and wherein the heating means is in the reservoir.

6. A unit as claimed in claim 5 and wherein the heating means surrounds the capillary.

7. A unit as claimed in any one of claims 1 to 6 and having an additional heating means for the supply fluid about to enter the evaporator.

8. A unit as claimed in any one of the preceding claims and wherein the fluid supply apparatus includes a pump, and the temperature control apparatus includes a temperature sensing means for sensing the supply fluid output temperature, a thermostatic control for the heater, and an on/off switch and manual temperature control for the supply fluid temperature.

9. A unit as claimed in any one of the preceding claims and wherein the supply fluid which the unit is adapted to provide is a liquid.

10. A unit as claimed in claim 9 and wherein the liquid is a water glycol.

11. A unit as claimed in any one of the preceding claims and associated with a conditioning suit.

12. A unit as claimed in claim 9 or claim 10 and associated with a liquid conditioned suit.

13. A unit as claimed in any one of claims 1 to 8 and wherein the fluid the unit is adapted to provide is air.

14. A unit as claimed in claim 13 which includes a fan for blowing air therefrom.

15. A unit as claimed in claim 14 and which is manually portable.

16. A unit substantially as hereinbefore described with reference to the drawing accompanying the Provisional Specification.

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Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1979
Published at the Patent Office, 25 Southhampton Buildings, London, WC2A 1AY, from which copies may be obtained.